Synopsis

Title of the proposed work:

Numerical Solution of Heat and Mass Transfer Problems in Constricted / Expanded Channel

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The flow field in the neighborhood of constrictions in tubes has been of great interest to fluid dynamics because of its many engineering applications. This type of configuration is used in heat exchanges in order to enhance heat transfer performance. An earlier numerical work on this type of problem was done by Lee and Fung [1] to study the flow in locally constricted tubes in the Reynolds number range 0-25. Lee et al. [2] investigated steady laminar flow through a variable constriction in a vascular tube. The separating flow through a severely constricted symmetric tube was studied analytically by Smith et al. [3]. The main separation was shown to take place on the upstream constriction surface. Wille et al. [4] studies the pressure and flow fields in arterial stenoses simulated by mathematical models. Sobey et al. [5] studied numerically the flow through furrowed channels and investigated the Reynolds number effects on the separated flow.

Cheng et al. [6] investigated steady viscous flow through a channel with symmetric cosinusoidal constrictions on both the walls at the same location. Vradis et al. [7] studied steady incompressible viscous flow in a channel with local constriction having the shape of a Gaussian distribution.

Mahapatra et al. [8] studied flow separation in a constricted channel without assuming flow symmetry about the channel centreline. They observed that with increasing Reynolds

number, the flow through a channel with smooth symmetric constriction may become asymmetric about the channel centreline.

For the case of symmetric sudden channel expansion, at low Reynolds numbers, there is no separation and the flow is symmetric. As the Reynolds number increases the flow separates from the walls with the formation of recirculation zones of unequal length and the flow becomes asymmetric. With further increase in Reynolds number, the asymmetric flow separates from one of the walls and gets attached to the other. This was found by several authors like Durst et al. [9,10], Cherdron et al. [11] and by Fearn et al. [12].

Asymmetry of flow in symmetric constriction has been calculated in different area reduction of the channel width. The critical Reynolds number at which the flow becomes asymmetric has been found. Results are compared with available numerical values. Flow asymmetry is shown by non-zero values of the centreline vertical velocity component and root-mean-square ($r.m.s.$) vertical velocity component on the channel centreline for different Reynolds numbers. As the Reynolds number increases, the asymmetry remains in the flow, even up to turbulent flow conditions as observed by Restivo and Whitelaw [13] . This phenomenon is referred to in the literature as the Coanda effect. Instabilities and bifurcations of channel flows have been investigated by Sobey and Drazin [14]. In more recent work, Pramanik et al. [15] numerically studied viscous flow through a symmetrically expanded channel,the flow becomes asymmetric about the channel centreline with increasing Reynolds number.

The control of boundary layer separation is of much practical interest in aerodynamics and in physiological flows. Several methods have been developed for the purpose of artificially controlling the behaviour of the boundary layer. The aim of these methods is to alter and organize the whole flow in a desired direction by influencing the structure of the boundary layer et al. [16]. Fluid flow separation and various boundary layer control techniques were described in Gad-el-Hak and Bushnell et al. [17]. The application of magnetohydrodynamic (MHD) principles is yet another method for affecting the flow field in a desired direction by altering the structure of the boundary layer.

Recently, Midya et al. [18]. investigated MHD viscous flow in a channel with constriction. They found that the flow separates downstream of the peak of the constriction and that, with increase in magnetic field the flow separation zone diminishes in size. For sufficiently large magnetic field, the separation zone disappears completely.

In recently, stability and transition to turbulence in plane channel flow have been investigated in several works. Stability thresholds of stream wise streaks and transition to turbulence in plane channel flow were investigated by Reddy et al. [19] . Direct numerical simulation was applied by Krasnov et al. [20] to investigate instability and transition to turbulence of flow of an electrically conducting incompressible fluid between two parallel unbounded insulating walls affected by a wall-normal magnetic field (the Hartmann flow).

We proposed to study flow, heat and mass transfer in a channel with single or double constriction or expansion with the help of double constriction or expansion with the help of isotherm, heatline, streamline etc. We also want to steady entropy generation in the flow situation. In this paper viscous flow of an electrically conducting incompressible fluid in a channel with asymmetric smooth expansion is studied numerically without assuming flow symmetry with respect to the channel centreline.A co-ordinate transformation has been used to map an infinite irregular domain into a finite rectangular computational domain. The governing equations have been discretized on a staggered grid using a finite-difference method, popularly known as MAC method [21,22].

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